

Appl. No. Not Assigned  
Prel. Amdt. Dated February 3, 2004  
Preliminary Amendment With Divisional

**Amendments to the Specification**

In the specification immediately following the title, please add the following paragraph.

This application is a divisional of Patent Application Serial No. 09/675,696 filed on September 29, 2000, and claims priority of that application.

Replace the paragraph on page 11, lines 20-32 with the following amended paragraph:

FIGs. 2 and 3 show one embodiment of the waveguide 12 used to construct the shutter switch 10. Its top and bottom walls 22 and 24 are conductive, and the inside of its sidewalls 23, 25 have high impedance structure 26. The structure 26 includes a sheet of dielectric material 28 with conductive strips 30 of uniform width on one side, the conductive strips 30 having a uniform gap 32 between adjacent strips 30. A layer of conductive material 34 is included on the side of the dielectric material 28 opposite the conductive strips 30. Vias 36 of conductive material are provided between the conductive strips 30 and the conductive layer 34, through the dielectric material 28. The conductive strips 32 are oriented longitudinally down the waveguide 12.

Replace the paragraph on page 12, line 20 to page 13, line 2 with the following amended paragraph:

Holes are created through the dielectric material 28 at uniform intervals, the holes continuing through the dielectric material 28 to the conductive strips 30 on the

other side. The holes can be created by various methods, such as conventional wet or dry etching. They are then filled or covered with the conductive material and the uncovered side of the dielectric material is covered with a conductive material, both accomplished using sputtered vaporization plating. The holes do not need to be completely filled but the walls of the holes must be covered with the conductive material. The covered or filled holes provide conductive vias 39 36 between the conductive layer ~~38~~ 34 and the conductive strips 34 30. The dimensions of the dielectric material 28, the ~~conductor~~ conductive strips 34 and the vias 39 depend on the particular design frequency for the waveguide 12.

Replace the paragraph on page 13, lines 3-21 with the following amended paragraph:

With the high impedance structure 26 on the waveguide's sidewalls such that the conductive strips run parallel to the waveguides longitudinal axis, the structure will present a high impedance to the E field component of a vertically polarized signal at the design frequency. As shown in FIG. 4, the gap 32 presents a capacitance 38 to the E field component that is transverse to the conductive strips. The capacitance 38 is primarily dependant upon the width of the gap 32 between the strips 30 but is also impacted by the dielectric constant of the dielectric material ~~26~~ 28. The structure 26 also presents an inductance 40 to a transverse E field, the inductance 40 being dependant primarily on the thickness of the dielectric material 28 and the diameter of the vias 36. At resonant frequency, the structure presents parallel resonant L-C circuits 42 to the vertically polarized signal

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and, as a result, a high impedance to a transverse E field. The E field maintains uniform power density across the waveguide, during transmission through the waveguide.

Replace the paragraph on page 13, line 28, to page 14, line 13 with the following amended paragraph:

The wall structure 26 also has a shorting switch ~~38~~ 39 at each of the gaps 32 that short their respective gap when closed, the details of the switches are described below and shown in FIGs. 11-14. When the switches ~~38~~ 39 are open, the structure functions as described above, presenting a high impedance to a transverse E field. The gaps 32 form the capacitive part of the resonant L-C circuits and by closing the switches ~~38~~ 39, the gaps 32 and their capacitance are shorted. The conductive strips 30 and closed switches 39 change the characteristics of the structure 26 such that it presents as a continuous conductive sheet. The waveguide 12 now has conductive sidewalls along with the conductive top and bottom walls. Because the waveguides physical dimension "A" in FIG. 2 is less than the critical dimension required for the frequency, signal transmission is cut-off and blocked. In the preferred embodiment, the switches ~~38~~ 39 in all the waveguides of the shutter switch 10 are closed simultaneously, causing all the waveguides to block transmission of the signal.

Replace the paragraph on Page 16, lines 10-18 with the following amended paragraph:

The structure 57 is manufactured using similar materials and processes described above for the embodiment shown in FIGs. ~~1 and 2~~ 2 and 3 , and the manufacturing of

the shorting switches is described below. By selectively closing the switches on opposing walls of the waveguide 50, the horizontal portion, vertical portion, or both, can be cut-off. A shutter switch constructed of these waveguides can selectively block portions of a cross-polarized beam, or the entire beam.

Replace the paragraph on Page 16, line 12 to page 17, line 4 with the following:

~~FIGs.~~ FIG. 7 shows another embodiment of the waveguide 70 used to construct the shutter switch 10. The waveguide has a three-layered high impedance 71 structure on its walls 72-75. In an alternative embodiment the structure 71 can be on the waveguides sidewalls 72, 74 with its top and bottom walls 73, 75 being conductive, or the structure can be on the waveguides top and bottom walls 73, 75 with its sidewalls 72, 74 being conductive. The structure 71 can have different numbers of layers, depending on the number of frequencies to be transmitted by the waveguide. The structure 71 shown has three layers and presents a high impedance to transverse E fields at three different resonant frequencies.

Replace the paragraph on Page 20, line 19 to page 21, line 5 with the following amended paragraph:

FIGs 10a-10c illustrate how the three signals interact with layers of the new structure 71. An important characteristic of the structure's layers 104, 106, and 108 is that each appears transparent to E fields at frequencies

below its design frequency, and the strips appear as a conductive surface to E fields at frequencies above its design frequency. For the highest frequency signal f1, the top layer 108 presents as high impedance resonant L-C circuits to the signal's transverse E field. The strips 110 on second layer 106 appear as a conductive layer and become a "virtual ground" for the top layer 108. Signal f2 is lower in frequency than f1 and, as a result, the first layer 104 is transparent to f2's E field, while the second layer ~~64~~ 106 appears as high impedance resonant L-C circuits. The ~~patches~~ strips 112 on the third layer appear as a conductive layer, becoming the second layer's virtual ground. Similarly, at f3 the top and second layers 108 and 106 are transparent, but the third layer 104 appears as high impedance resonant L-C circuits, with the conductive layer 114 being ground for the third layer 104.

Replace paragraph on Page 21, line 29, to page 22, line 12 with the following amended paragraph:

Shorting switches 116 are shown as symbols on the top layer of the structure 71 on the ~~top and bottom walls 73~~ walls 72-75, and the details of the switches are described below and shown in FIGs. 11-14. If the switches are closed on the top layer on all four of the waveguide's walls, the waveguide 70 is changed from transparent to opaque at all three frequencies. For instance, at the lowest frequency, when the first two layers of the structure appear transparent and closing the switches on the top layer shorts the gap capacitance and causes the signal to see only the conductive surface presented by the top layer's

conductive strips and closed switches. The same is true for the next higher frequencies. Closing the switches causes them to see only a conductive surface, cutting off transmission.

Replace the paragraph on Page 22, line 23, to page 23, line 9 with the following amended paragraph:

If switches 116 are included at each of the layers (not shown) then different frequencies at different polarizations can be selectively blocked. For example,  $f_3$  could be blocked in both polarizations if the switches 116 are closed on the bottom layer 82 (shown in FIG. 8) on all four walls. Only for  $f_3$  will ~~the~~ all the layers appear as conductive layers, cutting off transmission at  $f_3$ . If the shorting switches 116 are closed on the bottom layer 82 on the top and bottom walls 73, 75 only, transmission of the horizontally polarized signal at  $f_3$  is blocked, while still transmitting the vertically polarized signals at  $f_3$ . If the switches 116 are closed on the bottom layer 82 on the sidewalls, transmission of the vertically polarized signal at  $f_3$  is blocked. By selectively closing the switches 116 at the other layers 84, 86, the different frequencies in different polarizations can be blocked.

Replace the paragraph on Page 23, line 25, to page 24, line 7 with the following amended paragraph:

FIGs. 11, 12 and ~~23~~ 13, show one embodiment of the MEMS shorting switches ~~112~~ 132 constructed in accordance

with the present invention to short the conductive strips ~~114~~ 134 in the high impedance structure ~~110~~ 130. The switches ~~112~~ 132 are fabricated using generally known micro fabrication techniques, such as masking, etching, deposition, and lift-off. FIG. 11 is a sectional view of the high impedance structure ~~110~~ 130 taken transverse to the conductive strips ~~114~~ 134. FIG. 12 is a sectional view taken ~~long~~ along sectional lines of one of the shorting switches ~~112~~ 132. Both show high impedance structure's dielectric material ~~116~~ 136, vias ~~118~~ 138 and conductive layer ~~120~~ 140.

Replace the paragraph on page 24, lines 8-17 with the following amended paragraph:

The switches ~~112~~ 132 are manufactured by depositing semiconductor layer ~~120~~ 140 over the conductive strips ~~114~~ 134 and over the exposed surface of the dielectric material ~~116~~ 136, the preferred semiconductor material being Si<sub>3</sub>N<sub>4</sub>. Stand-off isolators ~~122~~ 142 are deposited at intervals down the gap between the conductive strips ~~114~~ 134 and are preferably formed of an insulator material such as silicon dioxide. A respective strip of metallic material ~~124~~ 144 is mounted over each of the gaps by affixing it on the top of the stand-offs ~~122~~ 142 along one of the gaps.

Replace the paragraph on page 24, lines 18-28 with the following amended paragraph:

In operation, each metallic strip ~~124~~ 144 has either 0

volts or voltage potential applied, with the preferred potential being 50 volts. With 0 volts applied, the strips ~~114~~ 134 remain suspended above their respective gap between the stand off isolators ~~122~~ 142 as shown in FIG. 12. The switches are in the "Off" state and the structure ~~110~~ 130 presents as a high impedance to the design frequency E field transverse to the conductive strips ~~114~~ 134. The gaps between the strips ~~114~~ 134 presents a capacitance and the vias ~~118~~ 138 present an inductance, with the structure presenting as a series of resonant L-C circuits to the transverse E field.

Replace the paragraph on Page 24, line 29 to page 25, line 10 with the following amended paragraph:

Referring now to FIG. 13, to close the switch ~~112~~ 132 and short the gap between conductive strips ~~114~~ 134 a 50 volt potential is applied to the metallic strips ~~124~~ 144. This causes an electrostatic tension between the metallic strips ~~124~~ 144 and the respective conductive strips ~~114~~ 134 below, pulling the switch strip down such that it makes capacitive contact with the strip ~~114~~ 134 on each side of the gap. This provides a conductive bridge across the gap, shorting the gap. With all the metallic strips ~~124~~ 144 pulled to the strips ~~114~~ 134 below, the high impedance structure appears as a conductive surface to the signal's E field. This switching network consumes very little and has a very fast closure time on the order of 30  $\mu$ s.

Replace the paragraph on Page 25, lines 11-19 with the following amended paragraph:

FIG. 14 shows a high impedance structure ~~140~~ 150 with a second embodiment of the shorting switches ~~142~~ 152 that



utilize varactor diode technology to short the gaps. The varactor diode is an ordinary junction diode that relies on its voltage dependent capacitance. Each varactor switch includes a N+ (highly conducting) layer ~~144~~ 154 grown or deposited in the each gap between the conductive strips ~~146~~ 156. An N- (moderately conducting) layer ~~148~~ 158 is grown on top of top of a portion of the N+ layer ~~144~~ 154.

Replace the paragraph on Page 25, lines 20-30 with the following amended paragraph:

In fabricating the switches ~~142~~ 152, the N+ and N- layers ~~144~~ 154 and ~~148~~ 158 are etched into mesas that will provide a strip of varactor material along the length of the gaps between the conductive strips ~~146~~ 156. The switching of the varactor is controlled by a second conductive strip ~~150~~ 160 sitting on an insulator layer ~~152~~ 162 that is sandwiched between the second strip ~~150~~ 160 and each conductive strip ~~146~~ 156. The insulator layer ~~152~~ 162 provides a capacitive coupling to conductive strip ~~146~~ 156 and the ground plane. Voltage applied to the second strip ~~150~~ 160 controls the capacitance of the varactor layer and thus the shorting of the gap.

Replace the paragraph on page 26, lines 9-27 with the following amended paragraph:

FIG. 15 shows millimeter beam transmission system ~~150~~ 170 used in various high frequency applications such as munitions guidance systems (e.g. seeker radar). A transmitter ~~152~~ 172 generates a millimeter signal ~~154~~ 174 that spreads as it moves from the transmitter. Most of the signal is directed toward a lens ~~156~~ 176 that collimates the signal into a beam ~~157~~ 177 with little diffraction.

The collimated beam travels to a second lens 158 that focuses the beam to a receiver ~~160~~ 180. The shutter switch ~~162~~ 182 is positioned between a millimeter wave transmitter ~~152~~ 172 and receiver ~~160~~ 180 such that it intercepts the transmission beam ~~157~~ 177. When the shorting switches on the shutter switch's waveguides are open, the shutter switch ~~162~~ 182 is transparent to the beam and the signal passes from the transmitter ~~152~~ 172 to the receiver ~~160~~ 180. When the shorting switches are closed, transmission of the signal through each of the waveguides is cut-off, making the shutter switch ~~162~~ 182 opaque to the beam ~~157~~ 177 and blocking transmission from the transmitter to the receiver.

Replace the paragraph on page 26, line 28, to page 27, line 2 with the following amended paragraph:

As described above, when the waveguides in the shutter switch ~~162~~ 182 have the high impedance structure on the sidewalls and the top and bottom walls, the beam can have horizontal and vertical polarization and the shutter switch ~~162~~ 182 can block one or both of the polarizations. When the high impedance structure has multiple layers, the shutter switch can be transparent or block signals at multiple frequencies and at one or both polarizations.

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**Amendments to Drawings**

The attached sheets of drawings include FIGs. 2, 3, 5, 6, 7, 10c, 11, 12, 13, 14 and 15 with changes to correct clerical errors.

Attachment:      Replacement Sheets  
                         Annotated Sheets Showing Changes